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Interchange motions, coherent structures, and intermittent transport in magnetized plasmas

O. E. Garcia, V. Naulin, A. H. Nielsen, and J. Juul Rasmussen

Association EURATOM–Risø National Laboratory,

OPL-128 Risø, DK-4000 Roskilde, Denmark

K. Rypdal

Department of Physics, University of Tromsø, N-9037 Tromsø, Norway

Electronic address: `odd.erik.garcia@risoe.dk`

Abstract

Low-frequency two-dimensional interchange motions in magnetized plasmas are investigated by means of long run numerical simulations allowing full profile variations. Numerous aspects of the non-linear evolution pertinent to ionospheric irregularities are considered. Non-linear numerical simulations which result in stationary convective states reveal the process of laminar scalar gradient expulsion, leading to the formation of plumes and vorticity sheets. These dissipative structures are demonstrated to result in profile consistency and transport scaling far from the linear instability threshold. Another self-organizing mechanism involves the generation of differential rotation by fluctuating motions through tilting of the convective structures. The role of kinetic energy transfer and shearing due to differential advection is pointed out. Numerical simulations show turbulent states with a bursty behavior of the fluctuation level which is associated with relaxation oscillations in the kinetic energy of the azimuthally mean flows. This leads to a state of large-scale intermittency manifested by exponential tails in the probability distribution functions of the dependent variables. Fluctuation bursts are associated with transient transport events due to coherent structures propagating along the direction of the driving pressure gradient, leading to convective overshoot and turbulence spreading into linearly stable regions. Statistical analysis of the simulation data reveals self-similar probability distributions and long-range correlations.